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Investigations of Laser Damage in Rapidly Grown KDP Crystals

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Abstract

The development of rapid crystal growth technology at LLNL has made it possible to produce high quality KDP and KD*P Pockel's cell, frequency doubler and tripler crystals for use in ICF lasers such as the National Ignition Facility (NIF) and Laser Megajoule (LMJ). Because of the high growth rates (>10mm/day) compared to conventionally grown crystals, fast growth technology offers substantial costs savings to NIF and LMJ. The NIF design specifications, however, call for maximum operational (redline) fluence of 14 J/cm^2 (351 nm, 3 ns pulse) for the third harmonic generation (THG) crystals. Currently neither fast grown nor conventionally grown KD*P crystals can meet the THG operational requirement without laser conditioning. To produce THG crystals which will survive the NIF redline it is paramount to understand the damage and conditioning mechanisms for KDP and KD*P crystals, especially at 3ω (351 nm).

We report on the results of experiments performed to understand laser damage and conditioning mechanisms in KDP grown at rates exceeding 10 mm per day. Using an optical scatter diagnostic we have determined that micron scale discrete (Mie) scatter points do not usually act as damage initiation sites and that a substantial number of preexisting scatter sites have been observed to vanish upon exposure to subthreshold 3ω fluences. Further, we have determined that damage usually initiates at points which show no precursors. Experiments to relate laser damage to refractive index variations also show low correlation.

UV absorption measurements have shown substantial differences between the optical density of prism and pyramidal sectors which are related to the incorporation of various impurities into the lattice during growth. Experiments have shown that there is also a low correlation of laser damage to large differences in bulk absorption. However, we have observed that large differences in impurity concentration can lead to high damage susceptibility at the prism/pyramid sector interface. We attribute this to strain in the crystal and have shown that damage thresholds at the boundary can be raised to the level of the surrounding bulk material through thermal annealing .

Recent experiments to determine the effect of continuous filtration of the growth solution on laser damage have shown that filtration may not be necessary for achieving high damage thresholds. We tested samples grown under nominally identical conditions except for solution filtration and the crystals showed identical unconditioned (S/1) and conditioned (R/1) behavior. Compared to the LLNL damage database these crystals had the highest R/1 thresholds ever attained for fast grown crystals. Damage tests of these crystals on systems with different pulse durations (at 3ω, 3 ns and 7.6 ns) have verified that bulk thresholds for KDP scale according to $\tau^{0.5}$. Test results on these crystals also indicate that there may be a fluence ramp rate dependence on the R/1 threshold.

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